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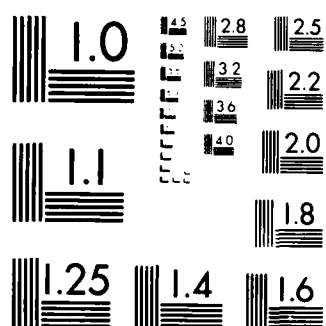
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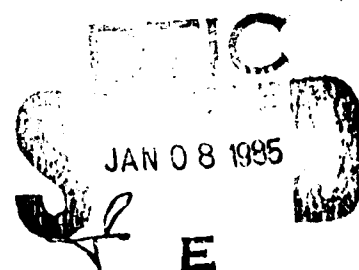
Organizations As Information Processing Systems

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Principal Investigators

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A Proposed Integration Among
Organizational Information
Requirements, Media Richness
and Structural Design

Richard Daft
Robert Lengel

TR-ONR-DG-10

November 1984



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level of equivocality and uncertainty that arise from organizational technology, interdepartmental relationships, and the environment.

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A PROPOSED INTEGRATION AMONG ORGANIZATIONAL INFORMATION REQUIREMENTS,
MEDIA RICHNESS AND STRUCTURAL DESIGN

RICHARD L. DAFT and ROBERT H. LENGEL

Abstract

This paper argues that information processing in organizations is influenced by two forces--equivocality and uncertainty. Equivocality is reduced through the use of rich media and the enactment of a shared interpretation among managers (Weick, [62]). Uncertainty is reduced by acquiring and processing additional data (Galbraith, [21]; Tushman and Nadler, [56]). Elements of organization structure vary in their capacity to reduce equivocality versus uncertainty. Models are proposed that link structural characteristics to the level of equivocality and uncertainty that arise from organizational technology, interdepartmental relationships, and the environment.

A PROPOSED INTEGRATION AMONG ORGANIZATIONAL INFORMATION REQUIREMENTS, MEDIA RICHNESS AND STRUCTURAL DESIGN

1. Introduction

Why do organizations process information? The answer most often given in the literature is that organizations process information to reduce uncertainty. This line of reasoning began when Galbraith [21] integrated the work of Burns and Stalker [7], Woodward [65], Hall [27], and Lawrence and Lorsch [29] in terms of information processing. Galbraith observed that a variable common to each study was the predictability of the organization's task. He explained variation in organizational form based upon the amount of information needed to reduce uncertainty and thereby attain an acceptable level of performance.

One purpose of organizational research and theory building is to understand and predict the structure that is appropriate for a specific situation (Schoonhoven, [47]). Information processing provides a useful tool with which to explain organizational design. Galbraith [21], [22] proposed structural characteristics and behaviors contingent upon organizational uncertainty, and a line of research and theorizing has provided support for this relationship. Studies by Tushman [54], [55], Van de Ven and Ferry [60], Daft and Macintosh [12], and Randolph [44] support a positive relationship between task variety and the amount of information processed within work units. Van de Ven, Delbecq, and Koenig [59] found that departmental communication increased as interdependence among participants increased. A number of other studies have found that either the amount or nature of information processing is associated with task uncertainty (Meissner, [34]; Gaston, [25]; Bavelas, [3]; Leavitt, [30]; Becker and Baloff, [4]).

Why do organizations process information? The organizational literature also suggests a second, more tentative answer: to reduce equivocality. This

answer is based on Weick's [62] argument that equivocality reduction is a basic reason for organizing. Equivocality seems similar to uncertainty, but with a twist. Equivocality presumes a messy, unclear field. An information cue may have several interpretations. New information may be confusing, and may even increase uncertainty. New data may not resolve anything when equivocality is high. Managers will talk things over, and ultimately enact a solution. Managers reduce equivocality by defining or creating an answer rather than by learning the answer from the collection of additional data (Weick, [62]).

Emerging research suggests that equivocality is indeed related to information processing. Daft and Macintosh [12] found that equivocal data were preferred for unanalyzable tasks, and managers used experience to interpret these cues. Lengel and Daft [31] reported that face-to-face media were preferred for messages containing equivocality, while written media were used for unequivocal messages. Putnam and Sorenson [43] found that subjects used more rule statements and diverse interpretations for high equivocal than for low equivocal messages. These findings suggest that when equivocality is high, organizations allow for rapid information cycles among managers, typically face-to-face, and prescribe fewer rules for interpretation (Weick, [62]; Daft and Weick, [14]).

Why do organizations process information? The literature on organization theory thus suggests two answers--to reduce uncertainty and to reduce equivocality. In some respects these answers may be similar, yet they are also distinct. Both answers say something about information processing, about how organizations and managers should behave in the face of these circumstances. Both answers have implications for the type of structure an organization should adopt to meet its information processing requirements.

The purpose of this paper is to integrate the equivocality and

uncertainty perspectives on information processing. The prevalent view in organization theory has been the concern for processing additional information to reduce uncertainty (Galbraith, [21], [22]; Tushman, [54]; Tushman and Nadler, [56]). This idea is important and is integrated with Weick's ideas about designing the organization to reduce equivocality through means other than obtaining more data. Specific organization structures are recommended depending on the extent of uncertainty and equivocality faced by the organization from its technology, departmental interdependence, and environment.

2. Background and Assumptions

Our approach to the study of organizations is based on several assumptions about organizations and information processing. The most basic assumption is that organizations are open social systems that process information. Information is processed to accomplish internal tasks, to coordinate diverse activities, and to interpret the external environment. Human social systems are more complex than lower level machine or biological systems (Boulding, [6]; Pondy and Mitroff, [41]). Many issues are fuzzy and ill-defined. Information cannot be fixed or routinized as in lower level systems. Although some organization situations can be considered orderly and logical, others are ill-structured or "wicked," because alternatives cannot be identified, data cannot be obtained or evaluated, and outcomes of various actions are unpredictable (Cohen, March and Olsen, [10]; Weick, [61]). To survive, organizations develop information processing mechanisms capable of coping with variety, uncertainty, coordination, and an unclear environment.

The second assumption pertains to level of analysis in organizations. Individual human beings process information in organizations, yet we assume that organizational information processing is more than what occurs by

individuals (Hedberg, [28]; Daft and Weick, [14]). One distinguishing feature of organizational information processing is sharing. Individual level decision making presumes the acquisition of data in response to a problem (Simon, [50]; Ungson, Braunstein, and Hall, [57]). Information processing at the organization level, however, typically involves several managers who converge on a similar interpretation. Another distinguishing feature of organization information processing is the need to cope with diversity not typical of an isolated individual. Decisions are frequently made by groups so that a coalition is needed. But coalition members may have different interpretations of the same event, may be pursuing different organizational priorities or goals, and hence may be in conflict with respect to the information or its use for goal attainment (Ungson, et al., [57]). Information processing at the organization level must bridge disagreement and diversity quite distinct from the information activities of isolated individuals.

The final assumption is that organization level information processing is influenced by the organizational division of labor. Organizations are divided into subgroups or departments. Each department utilizes a specific technology that may differ from other departments (Hall, [27]; Van de Ven and Delbecq, [58]; Daft and Macintosh, [12]). For the organization to perform well, each department must perform its task, and the tasks must be coordinated with one another. In an information view, the organization is a series of nested subsystems. Uncertainty and equivocality may arise from within the subsystems (technology), from coordination of the subsystems (interdependence), or from the external environment. Organizational level information processing thus may depend upon the nature of the task to be performed, on requirements for coordination, or on the nature of the external environment (Tushman and Nadler, [56]). These factors determine the pattern of events and activities

which influence the level of uncertainty or equivocality experienced by the organization.

3. Uncertainty versus Equivocality

Based on early work in psychology (Miller and Frick, [35]; Shannon and Weaver, [48]; Garner, [24]), uncertainty has come to mean the absence of information. As information increases, uncertainty decreases. Uncertainty can be illustrated by a typical laboratory experiment. Laboratory subjects might play the game of twenty questions, wherein they receive yes-no answers to questions about the identity of an unknown object, which can be animal, vegetable or mineral (Bendig, [5]; Taylor and Faust, [52]). The "information" obtained from each answer can be precisely calculated as the improvement in the subject's ability to identify the object. Improvement in identifying the object is also a reduction in uncertainty. When the person identifies the object correctly, uncertainty is gone so additional questions provide no additional information.

The definition of uncertainty as the absence of information persists in organization theory today (Tushman and Nadler, [56]; Downey and Slocum, [18]). Galbraith defined uncertainty as "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization" (Galbraith, [22]). Organizations that face high uncertainty have to ask a large number of questions and to acquire more information to learn the answers. The organization can structure itself to provide answers to managers through management information systems, periodic reports, rules and procedures, or face-to-face meetings. The important assumption underlying this approach, perhaps originating in the psychology laboratory, is that the organization and its managers work in an environment where questions can be asked and answers obtained. New data can be acquired

so that tasks can be performed under a satisfactory level of certainty.

Equivocality, in contrast to uncertainty, means ambiguity, the existence of multiple and conflicting interpretations about an organizational situation (Weick, [62]; Daft and Macintosh, [12]). High equivocality means confusion and lack of understanding. Equivocality means that asking a yes-no question is not feasible. Participants are not certain about what questions to ask, and if questions are posed, the situation is ill-defined to the point where a clear answer will not be forthcoming (March and Olson, [33]). For example, Mintzberg, et al., [36] examined twenty five organizational decisions, and in many cases did not find the uncertainty described in the textbook where alternatives could be defined and information obtained. They found instead decision making under ambiguity where almost nothing was given or easily determined. Managers had to define and figure things out for themselves. Little data could be obtained. Uncertainty as studied in the psychology laboratory did not characterize the ambiguity experienced by managers. A laboratory situation analogous to the ambiguity faced by managers would be to provide subjects with partial or contradictory instructions for the experimental game, or to leave it to subjects to figure out and create their own game.

Thus we propose that two forces exist in organizations that influence information processing. One force is defined as uncertainty and is reflected in the absence of answers to explicit questions as has been studied in laboratory settings; the other force is defined as equivocality and originates from ambiguity and confusion as often seen in the messy, unclear world of organizational decision making. Each force has value for explaining information behavior, but they lead to different behavioral outcomes. Equivocality leads to the exchange of existing views among managers to define problems and resolve conflicts through the enactment of a shared

interpretation that can direct future activities. Uncertainty occurs when problems have been defined, and leads to the acquisition of objective information about the world to answer specific questions.

The two causes of information processing are combined into a single framework in Figure 1. The horizontal axis in Figure 1 represents organizational uncertainty. Under conditions of high uncertainty, the organization acquires data to answer objective questions and solve known problems. The vertical axis in Figure 1 represents equivocality. Under conditions of high equivocality, managers exchange opinions to clarify ambiguities, define problems, and reach agreement. As a framework for analysis and discussion, equivocality and uncertainty are treated as independent constructs in Figure 1 although they are undoubtedly related in the real world. High levels of equivocality may require some new data as well as clarification and agreement. Circumstances that demand new data may also generate some need for additional interpretation and definition. However, as independent constructs, the two dimensions in Figure 1 provide theoretical categories that can help explain both the amount and form of information processing in organizations.

Figure 1 About Here

Cell 1 represents a situation that is equivocal and poorly understood. Managers may not know what questions to ask nor agree about what problem to solve. Managers rely on judgment and experience to interpret events. They exchange views to enact a common perception. Answers are obtained through subjective opinions rather than from objective data. One example would be the feasibility of acquiring Corporation X. Would it fit strategically and organizationally and accomplish the desired outcomes? No one knows; no data

can say for sure. Managers can only discuss this equivocal issue until they define whether a problem exists and acquiring Corporation X is their solution. Goal setting is another example. Managers from engineering, marketing, and production may disagree about goal emphasis for the company, and no outside data will resolve this issue. They can discuss and exchange views until a common priority is enacted. Another approach to Cell 1 equivocality include responses like the Delphi technique (Delbecq, Van de Ven, and Gustafson, [17]) and dialectical inquiry (Mitroff and Emshoff, [37]). These techniques arrange for the exchange or even clash of subjective opinions when no objective data is available to predict an event or formulate strategy. The Delphi technique, for example, is appropriate for many ill-structured problems. Written judgments are exchanged so that each participant has the benefit of others' opinions. Through the process of formally exchanging information, a common grammar and judgment evolves, equivocality is reduced, and a common perspective emerges.

Cell 4 represents a situation where uncertainty is high. Equivocality is low, but managers need additional information. They know what questions to ask and the source of external data. For example, if turnover among clerical employees is increasing, managers might conduct a survey of reasons for leaving. If the question pertains to the reaction of customers to certain product colors and labels, a special study may provide the answer. If inventory outages cause customer alienation, data about customer ordering patterns may lead to an algorithm for inventory management. Information processing in this situation involves data acquisition and systematic analysis. Cell 4 uncertainty represents the absence of explicit information. The organization is motivated to acquire and process data to answer important questions.

In Cell 2, both equivocality and uncertainty are high. Many issues are

poorly understood and participants may be in disagreement. Subjective information processing to resolve differences and enact agreement is required. Issues also may be amenable to the gathering of new data that may influence managers' interpretation of events. A special study might be undertaken to gather data that can be combined with discussion and managerial judgment to reduce both equivocality and uncertainty. A Cell 2 situation would probably be characterized by rapid change, unanalyzable technology, unpredictable shocks, and a trial and error learning approach (Daft and Weick, [14]). Cell 2 could occur during times of rapid technological development, within emerging industries, or during the launching of new products. Some answers can be obtained through rational data collection, and other answers require subjective experience, judgment, discussion and enactment.

Cell 3 represents a low level of both equivocality and uncertainty. New problems do not arise with sufficient frequency to require significant additional data. Issues are well understood so discussion and judgment are not required to resolve and clarify issues. An organization in this situation would tend to rely on a standing body of information in the form of standards, procedures, policies, and precedents. Routine schedules, reports, and statistical data could be the information base that the organization uses. A Cell 3 situation is typified by an organization that uses a routine technology in a stable environment.

Figure 1 represents an attempt to organize the concepts of equivocality and uncertainty into a single framework. The framework suggests that uncertainty and equivocality may lead to different information requirements within organizations. The quadrants in Figure 1 represent patterns of problems and issues that influence organizational information responses and ultimately the structural design of the organization. Structure can be designed to facilitate discussion and equivocality reduction or to provide

data to reduce uncertainty, depending on organizational needs.

4. Structural Alternatives for Information Processing

We have argued that information processing in organizations is not fully conceptualized as obtaining data to reduce uncertainty. Organizations also interpret equivocal events for which data are not available. Equivocal issues are resolved through discussion and debate that consolidates managerial judgment into an enacted answer.

The next question is how can organizations be designed to meet the needs for uncertainty and/or equivocality reduction. Organization structure is the allocation of tasks and responsibilities to individuals and groups within the organization, and the design of systems to ensure effective communication and integration of effort (Child, [9]). Organization structure and internal systems facilitate interactions and communications for the coordination and control of organizational activities.

Information Amount. With respect to the uncertainty concept, structural characteristics have been defined in the literature as varying in the amount of information they provide for management coordination and control (Galbraith, [21]; Tushman and Nadler, [56]). Formal management information systems, for example, have the capacity to carry more data than rules and schedules. Formal systems can provide data about production work flow, employee absenteeism, productivity, down time, and can systematically provide data about the external environment and competition (Parsons, [38]). Other structural mechanisms include task forces and liaison roles. A task force has greater information capacity for an organization than a single face-to-face meeting. Liaison personnel can actively exchange data needed to reduce uncertainty. A number of studies have indicated that information processing increases or decreases depending on the complexity or variety of the

organization's task (Tushman, [54], [55]; Daft and Macintosh, [12]; Bavelas, [3]; Leavitt, [30]). Specific structural mechanisms can be implemented by the organization to facilitate the amount of information needed to cope with uncertainty and achieve desired task performance.

Information Richness. With respect to the equivocality concept, structural mechanisms have to enable debate, clarification, and agreement more than provide large amounts of data. The key factor in equivocality reduction is the extent to which structural mechanisms convey rich information (Daft and Lengel, [11]; Lengel and Daft, [31]). Richness is defined as the information-carrying capacity of data. If an item of data, such as a wink, provides substantial new understanding, it would be considered rich. If a datum, such as a number on a sheet, provides little understanding, it would be low in richness. Lengel and Daft [31] proposed that communication media vary in the richness of information processed. In order of decreasing richness, the media classifications are (1) face-to-face, (2) telephone, (3) personal documents such as letters or memos, (4) impersonal written documents, and (5) numeric documents. The reason for richness differences include the medium's capacity for immediate feedback, the number of cues and channels utilized, personalization, and language variety (Daft and Wiginton, [15]). Face-to-face is the richest medium because it provides immediate feedback so that interpretation can be checked. Face-to-face also provides multiple cues via body language and tone of voice, personal contact, and message content is expressed in natural language. Rich media facilitate equivocality reduction by enabling managers to overcome different frames of reference and by providing the capacity to process complex, subjective messages (Lengel and Daft, [31]). Media of low richness process fewer cues and restrict feedback, but are efficient for processing unequivocal messages and standard data about which managers agree.

Structure mechanisms that use rich media are personal and involve direct contact between managers, while structural mechanisms of less richness are impersonal and rely on rules, forms, procedures, or data bases. Van de Ven, Delbecq, and Koenig [59] found that coordination mechanisms varied along a continuum from group, personal, to impersonal depending upon the level of nonroutineness and interdependence. When task nonroutineness or interdependence were high, information processing shifted from impersonal rules to personal exchanges including face-to-face and group meetings. Lengel and Daft [31] found that rich communications were used by managers for difficult and equivocal messages. Rich information transactions allow for rapid feedback so that managers can converge on a common interpretation, and provide multiple cues, including body language and facial expression. When messages were unequivocal, Daft and Lengel found that less rich media, such as written memos or formal reports, were sufficient to meet information needs. Finally, Daft and Macintosh [12] suggested that qualitative, face-to-face techniques were suited to equivocal situations.

Structural Characteristics. Taken together, these ideas and findings begin to suggest how organizations handle dual information needs for both uncertainty and equivocality reduction, for both obtaining objective data and exchanging subjective views. We propose that seven structural mechanisms fit along a continuum with respect to their relative capacity for reducing uncertainty or for resolving equivocality for decision makers. This continuum is illustrated in Figure 2. The continuum reflects the relative need for uncertainty reduction versus equivocality resolution, and suggests that structural mechanisms may address both needs simultaneously.

Figure 2 about here

1. Group meetings. Group meetings include teams, task forces, and committees (Galbraith, [21]; Van de Ven, et al., [59]). A matrix structure utilizes frequent group meetings as a means of coordination. The comparative advantage of group meetings is equivocality reduction rather than data processing. Participants exchange opinions, perceptions and judgments face-to-face. Some new data may be processed, but the advantage of group meetings is the capacity to reach a collective judgment. Through discussions a cross-section of managers reach a common frame of reference (Weick, [62]). Managers can reach convergence about the meaning of equivocal cues, and are able to enact or define a solution. The strength of group meetings is the ability to build understanding and agreement. Group discussion is a subjective process rather than the collection of hard data for rational analysis.

2. Integrators. Integrators represent the assignment of an organizational position to a boundary spanning activity within the organization. Full-time integrators include product managers and brand managers (Galbraith, [21]; Lawrence and Lorsch, [29]). Part time integrators include liaison personnel whose responsibility is to carry information and reach agreement across departments, such as might be done by a manufacturing engineer (Galbraith, [21]; Reynolds and Johnson, [45]). The integrator role may include the acquisition of data, but it is primarily a mechanism for face-to-face and telephone meetings to overcome disagreement and thereby reducing equivocality about goals, the interpretation of issues, or a course of action. When managers approach a problem from diverse frames of reference, equivocality is high. Integrators and boundary spanners process rich information to resolve these differences, but they may also accumulate and process data to some extent.

3. Direct contact. Direct contact represents the simplest form of

personal information processing. When a problem occurs, Manager A can contact Manager B for a brief discussion, such as how to get production back on schedule (Galbraith, [22]). Direct contact can occur laterally between departments or vertically between hierarchical levels. Direct contact involves rich media, thus is similar to group meetings and integrator roles, although written memos and letters also may be used. Direct contact allows managers to exchange views and disagree, hence this mechanism facilitates subjective information as well as objective data. Through discussion and exchange of viewpoints, equivocality is reduced and some new data can be exchanged.

4. Planning. Planning is a dynamic process that includes elements of both equivocality reduction and data sharing. In the initial stages of planning, equivocality is high. Managers often meet face-to-face and in groups to decide overall targets and a general course of action (Steiner, [51]). Once plans are set, equivocality is reduced, and the plans become a less rich data processing device. Schedules can be defined and feedback mechanisms established. Comparing actual performance to targets provides managers with data to evaluate performance (Lorange and Vancil, [32]). Planning is near the middle of the scale in Figure 2 because it can play either an equivocality reduction or a data processing function. Planning resolves equivocality, while plans and schedules provide data for uncertainty reduction.

5. Special reports. Special reports include one-time studies, surveys, and project work. The purpose of special reports is to gather data about an issue, synthesize it, and report it to managers (Lengel and Daft, [31]). This process may involve some equivocality reduction, but its primary role is to obtain data, interpret it, and thereby reduce uncertainty. Managers know which question to ask before a study is requested. Special studies tend to be

undertaken for problems about which objective data is not available but can be obtained through systematic investigation and analysis.

6. Formal information systems. Formal information systems are the periodic reports, often computer based, that make up the organization's information system (Saunders, [46]). The information system includes computer reports, performance evaluations, budgets, and statistical information on such things as scrap rates, credit defaults, or market share (Daft and Macintosh, [12]). These reports are moderate to low in richness, and their purpose is to provide data to managers. The reports reduce managers' uncertainty about how well a new product is selling, or whether scrap rates are within the standards for each machine shop. Periodic reports typically pertain to the better understood and measurable aspects of organization and, hence, do not serve to reduce equivocality. Minor disagreements about interpretation might occur, in which case managers could either request additional data or resolve the issue through discussion.

7. Rules and regulations. Rules and regulations are perhaps the weakest and least rich information processing device (Galbraith, [21]; Tushman and Nadler, [56]). They are generally established to provide a known response to problems that have arisen in the past. Rules prescribe how to react in the future. Rules and regulations typically apply to recurring, well understood phenomena, and they reduce the need to process data on a continuous basis. Rules and programs therefore play almost no part in equivocality reduction. Equivocality is reduced before rules and procedures are written. Rules, procedures, standards, and policies provide an objective knowledge base from which employees can learn to respond to routine organization phenomena.

The placement of structural alternatives along the Figure 2 continuum is tentative. The information role of each structural mechanism may vary across organizations. The point of Figure 2 is to identify structural mechanisms

from the literature that pertain to the dual needs for equivocality and uncertainty reduction. The relationship of structure with equivocality and uncertainty has not been empirically tested, but the Figure 2 pattern is consistent with previous research. Van de Ven, et al. [59] found group, personal, and impersonal mechanisms were used according to interdependence and task nonroutineness. Daft and Macintosh [12] reported qualitative information was used for equivocal issues and quantitative information was used for unequivocal issues. Galbraith [21] and Tushman and Nadler [56] argued that some mechanisms have greater information capacity for use in uncertain situations.

One insight from Figure 2 is that information processing mechanisms may not be readily substituted for one another. For example, task forces and management information systems both have the capacity for high levels of information processing (Galbraith, [21]; Tushman and Nadler, [56]), but the underlying purpose of each form of information processing is radically different. Management information systems provide objective data, while task forces and group meetings are a rich medium that can serve the purpose of reducing equivocality and reaching agreement. Information systems do not reduce equivocality because equivocal issues are not easily measured and communicated through impersonal mechanisms. Likewise, task force meetings are not efficient mechanisms for disseminating large amounts of objective data.

5. Application to Organization Design

The final step in answering the question of organizational information processing is to translate the ideas from Figures 1 and 2 into organizational applications. Three sources of organizational uncertainty and equivocality are technology, interdepartmental relations, and the environment (Galbraith, [22]; Tushman and Nadler, [56]; Daft and Macintosh, [12]; Weick, [62]).

Technology is the transformation process within major departments, and interdepartmental relations reflect the linkage and coordination required between departments. The environment consists of the events, organizations, and problems external to the organization that are interpreted for adaptation, strategy formulation and survival (Duncan, [19]; Weick and Daft, [63]). Structural mechanisms similar to those in Figure 2 can be used to reduce equivocality or uncertainty arising from the technology within departments, relationships between departments, or to interpret the external environment.

Technology

Technology pertains to the knowledge, tools, and techniques used to transform inputs into organizational outputs. Perrow [39] proposed a technology model that defined two underlying task characteristics--task variety and task analyzability. Task variety is the frequency of unexpected and novel events that occur in the conversion process. High variety means that participants typically cannot predict problems or activities in advance. Task analyzability concerns the way individuals respond to problems. When the conversion process is analyzable, employees typically follow an objective, computation procedure to resolve problems. When work is not analyzable, participants have difficulty seeing into the task, and hence rely on judgment and experience rather than on rules and computational procedures. Perrow's model of technology is in Figure 3, along with proposed structural methods for processing information.

Figure 3 about here

Based upon the work of Van de Ven, et al. [59], Daft and Macintosh [12], Lengel and Daft [31], and the ideas proposed here, different modes of

information processing are proposed to occur for each technology. For craft technology (Cell 1), tasks are not analyzable, but few problems arise. These equivocal issues could be handled by personal contact and occasional discussions between managers. Experience is also used to interpret equivocal cues. Planning may be useful to reduce equivocality and anticipate problems. For nonroutine technologies (Cell 2), group meetings will be a primary source of information processing. Uncertainty is high because of frequent unanalyzable problems. People will use rich media in the form of frequent unscheduled meetings to resolve issues ad hoc, as well as scheduled meetings to coordinate departmental activities. In the case of engineering technologies (Cell 4), management information systems and special studies will be important. Tasks are analyzable, so they can be studied and problems thereby solved. Periodic reports from the formal information systems will cover a number of activities, and special projects and surveys can be used for issues not covered by the regular information system. Management information in both written and statistical form will provide information of appropriate richness for this kind of activity. In the case of routine technology (Cell 1), a standard body of rules, regulations, and policies can guide the routine activities. Occasional scheduled meetings may also be relevant here, but organization design will tend to facilitate impersonal data.

Of course each form of information processing will be used occasionally in each technology. But the emphasis and frequency of use is expected to differ. Formal statistics and management information systems will not be of great value in a basic research setting or for a craft technology, because "numbers" do not capture the intangible nature of these activities. Face-to-face discussions are needed to interpret and understand even . . . Likewise, personal and group meetings will play a smaller role in the engineering and routine technologies, but special studies, formal information

systems, and standard rules and procedures will play a larger role.

Interdepartmental Relations

The second source of uncertainty and equivocality is the need for coordination across departments. Galbraith [21] called this lateral information processing and recommended techniques such as direct contact, liaison roles, and integrators to achieve interdepartmental coordination.

The interdepartmental characteristic that influences equivocality is differentiation (Daft and Lengel, [11]). Each department develops its own functional specialization, time horizon, goals, frame of reference and jargon (Lawrence and Lorsch, [29]; Shrivastha and Mitroff, [49]). Bridging wide differences across departments is a problem of equivocality reduction. People come to a problem with different experience, cognitive elements, goals, values, and priorities. A person trained as a scientist may have a difficult time understanding the point of view of a lawyer. A common perspective does not exist. Coding schemes are dissimilar. Interdepartmental communications can be complex, ambiguous and difficult to interpret (Allen and Cohen, [2]; Gruber, et al., [26]). Equivocality is high when differentiation is large. The structural devices should enable participants to confront and resolve disagreement and misunderstanding that can arise between departments.

The characteristic that influences uncertainty between departments is strength of interdependence. Interdependence means the extent to which departments depend upon each other to accomplish their tasks (Thompson, [53]). Some departments work independently while other departments must continuously adjust to one another. Interdependence increases uncertainty because action by one department can unexpectedly force adaptation by other departments in the dependency chain. Frequent adjustments are needed when interdependence is high, and hence more information will be processed (Van de Ven, et al., [59]).

When interdependence is low, departments experience greater autonomy, stability and certainty.

Figure 4 combines the dimensions of differentiation and interdependence into a framework. Differentiation is associated in the equivocality reduction, and interdependence with uncertainty (Daft and Lengel, [11]). In Cell 1, departments have different frames of reference but are relatively independent so information processing will be infrequent. When it does occur, however, the primary aim will be to resolve equivocality and achieve a common grammar. For these occasional interactions, rich face-to-face or telephone discussions may resolve the issue, and some things can be handled by personal memos or anticipated in the planning process.

Figure 4 about here

When departments are both highly differentiated and interdependent, as in Cell 2, the information processing mechanisms of the organization will be extensively utilized. Wide differences must be resolved and a high volume of data must be processed to enable mutual adjustment. The organization will have to use structural mechanisms that allow both a high volume of information and rich media. Structures will include full-time integrators, task forces, and project teams. Direct contact in the form of political activity may also be used to negotiate across department boundaries (Gantz and Murray, [23]). Matrix organization structure may apply because it is designed to encourage frequent face-to-face meetings to ensure coordination laterally across the organization (Davis and Lawrence, [16]).

When differentiation is small, such as between an industrial engineering and mechanical engineering department, but interdependence is high, as in Cell 4, a different form of coordination will apply. These departments can rely

more heavily on high volume impersonal communications. Information can be exchanged through plans, reports, schedules, updated data bases, charts, budgets and memos. Much coordination can be achieved through less rich media because equivocality is low.

Finally, in Cell 3 interdependence and differentiation are both low, so the information needed for coordination will be minimal. Cell 3 is similar to the pooled interdependence described by Thompson [53]. A series of branch banks have similar perspectives and little need for interaction, so they can be coordinated through standardized rules and operating procedures. Personal or group contact is infrequent because there is little equivocality to be resolved and little need for mutual adjustment.

Environment

The final source of organizational information processing is interpretation of the external environment. The environment is a major factor in organizational structure and internal processes (Duncan, [19]; Pfeffer and Salancik, [40]). As an open system, an organization cannot seal itself off from the environment (Thompson, [53]). The organization must have mechanisms to learn about and interpret external events.

Weick's [62] discussion of equivocality pertained to interpretation of the environment. The environment contains many events that are inherently unclear. Managers discuss these events and enact a definition and common grammar so that organizational action may follow. Likewise, data can be accumulated to reduce uncertainty about such things as market share and customer demographics. Information processing from the external environment contains the dual needs of equivocality and uncertainty reduction.

Figure 5 is adapted from Weick and Daft [63] (Daft and Weick, [14]) and illustrates the relationship between the organization's environment and the

dual information processing needs. Equivocality is related to the analyzability of cause-effect relationships in the external environment (Thompson, [53]). When environmental relationships are clear and analyzable, equivocality is low, and managers can rely on the acquisition of explicit data to answer questions that arise. When the cause-effect relationships are unanalyzable, information processing must reduce equivocality. Managers must discuss, argue, and ultimately agree on a reasonable interpretation that makes action sensible and suggests some next steps. The interpretation process in the case of an unanalyzable environment is more personal and improvisational than for organizations facing well defined events.

Variation in analyzability of the environment is consistent with findings in the literature. Wilensky's [64] work on intelligence gathering in government organizations detected major differences in the extent to which environments were seen as rationalized, that is, subject to discernable, predictable uniformities in relationships among significant objects. Aguilar [1] studied managerial scanning and observed one organization that assumed an analyzable environment. Managers could construct accurate forecasts because product demand was directly correlated to petroleum demand, population growth, auto sales, and gasoline consumption. In a similar organization in another industry, statistical trends had no correlation with product demand or capital spending.

Figure 5 about here

The variation in uncertainty in Figure 5 is related to the amount of data collected about the external environment. Organizations range from being passive with respect to data collection to those who actively search the environment on a continuous basis (Fahey and King, [20]; Aguilar, [1]). When

the environment is perceived as hostile, competitive, rapidly changing, or when the organization depends heavily on the environment for resources, the organization gathers more data about the environment (Pfeffer and Salancik, [40]; Wilensky, [64]). Organizations develop multiple lines of inquiry into the environment because managers feel uncertainty. Organizations in benevolent, stable, noncompetitive environments have less incentive to gather data (Wilensky, [64]; Hedberg, [28]) because uncertainty is low.

Based upon these ideas, organizations in Cell 1 of Figure 5 do not actively seek environmental data, but do reduce equivocality. Rich media are used to interpret events, and insights are obtained from personal contacts with significant others in the environment. Data tend to be personal, nonroutine and informal, and are obtained as the opportunity arises. In Cell 2, organizations are more active. Organizations combine the acquisition of new data with the creation of new interpretations about the environment. Managers may reduce equivocality through trial and error experimentation as well as by acquiring more data about the external environment. Frequent meetings and debates would occur. In Cell 4, formalized search is the primary information vehicle. This organization has a well-defined environment which can be measured and analyzed through questionnaires, surveys, and other means of formal data collection. Managers reduce a high level of uncertainty by asking questions through management information systems, special purpose reports, and scanning departments. In Cell 3, neither equivocality nor uncertainty is high. The organization has established rules, procedures, reports, and information systems that reduce the need for extensive information. The environment is not hostile and the organization has little need to collect large amounts of environmental data.

6. Summary and Conclusion

This paper began by asking the question, "Why do organizations process information?" The answer we have proposed is to manage both uncertainty and equivocality. Uncertainty and equivocality represent two forces identified in the literature that influence information processing. Organizations can be structured with personal or impersonal mechanisms to manage equivocality and uncertainty to acceptable levels. We also proposed that technology, interdepartmental relations, and the environment are sources of both uncertainty and equivocality for organizations. Depending on the nature of the technology, interdepartmental relationships, and the environment, structural mechanisms can be adopted to meet management's needs for additional data or to create a common grammar and interpretation for ambiguous events.

The purpose of this paper was to tie together a number of threads from the organizational literature as indicated in Figure 6. The notions of uncertainty and equivocality, of structural mechanisms to reflect information needs, media richness, and of technology, interdependence, and environment as causes of information processing, have been presented in the literature previously. This paper attempted to integrate equivocality with uncertainty and argue that structural mechanisms are used to help organizations cope with these two factors. We also attempted to show that research pertaining to technology, interdepartmental relationships, and environment have common themes consistent with the equivocality/uncertainty framework. Figure 6 is adapted from Tushman and Nadler [56], and illustrates how organizational context influences uncertainty and equivocality, and that effective design will provide the appropriate amount and richness of information.

Figure 6 about here

This paper also offered a preliminary answer to a second and related question, "How do organizations process information?" Figure 2 and the frameworks for technology, interdepartmental relationships, and environment proposed specific structural mechanisms to enable the correct amount and type of information processing. Each structural mechanism—from rules and procedures to group meetings—was proposed to have a specific role that enabled the reduction of equivocality or uncertainty.

The synthesis of ideas presented in this paper suggests specific themes about organizational information processing that can be tested in future research. For example, the lack of clarity confronting managers in organizations may be as important to structural design and information processing as the need to obtain explicit data to reduce uncertainty. Previous research has measured information processing by counting communication activities such as the number of letters, phone calls, or oral communications, or by examining the geometry or frequency of data flow between specific points in the organization (Tushman, [54]; Bavelas, [3]; Allen and Cohen, [2]). These studies have made important contributions, but they assume a reasonably well defined field for managers and that data flow is sufficient for understanding information processing. The frameworks proposed in this paper imply that data counting may oversimplify information management within organizations. A major problem for organizations is lack of clarity, not lack of explicit data. The solution to equivocality is for managers to develop and agree upon a definition of the situation. The nature of equivocality and its impact on managers represent a new and potentially important avenue of research into information processing. Some preliminary studies have already been undertaken (Putnam and Sorenson, [43]), but additional research is needed to understand the process and impact of equivocality within organizations.

Other lines of research include the analysis of specific structural

characteristics as proposed in Figures 3, 4 and 5. For example, the difference between personal and impersonal mechanisms could be tested in the laboratory. Subjects could be asked to resolve a specific interdepartmental problem that could be high or low in equivocality, but subjects would be restricted to certain modes of information exchange. This research could even be a replication of the early work on group communication networks (Bavelas, [3]; Leavitt, [30]). The original research restricted group members to the use of written (impersonal) media. A replication that would allow controlled personal contact could shed light on the extent to which personal media are more or less effective for certain problems.

In the case of environmental scanning, an interesting question is how organizations obtain a clear view of where it fits within the environment and where it is going. Perhaps organizations could be simulated in a laboratory (Cameron and Whetten, [8]) and monitored for the types of information mechanisms that evolve to reduce ambiguity and manage uncertainty. Various levels of uncertainty and equivocality could be designed into the experiment. Field studies that explore how organizations scan and interpret the external environment could also make a valuable contribution.

In summary, Boulding [6] argued that human social systems are the most complex of all systems. A major characteristic that distinguishes social systems from lower level mechanical and biological systems is equivocality. Social systems do not work with machine like precision, and human beings have the capacity to cope with and respond to ambiguity. Yet the concept of equivocality has not been included in most studies and models of information processing. Bringing equivocality into future studies of organizational information processing may provide a richer and more accurate viewpoint to explain why organizations behave as they do. Future research may be able to elaborate and test the ideas presented in this paper and to further define the

underlying relationships between patterns of equivocality/uncertainty and their match with organization structure and design.

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EQUIVOCALITY	High	<p>1. High Equivocality, Low Uncertainty</p> <p>Ambiguous, unclear situation, define questions, develop common grammar, gather opinions</p>	<p>2. High Equivocality, High Uncertainty</p> <p>Ambiguous, unclear situation, define questions, seek answers, gather data and opinions</p>
	Low	<p>3. Low Equivocality, Low Uncertainty</p> <p>Clear, well-defined situation, few answers needed, routine data, objective</p>	<p>4. Low Equivocality, High Uncertainty</p> <p>Clear, well-defined situation, many questions, seek explicit answers, gather new data, objective</p>
		Low	High
		UNCERTAINTY	

Figure 1. Hypothesized impact of equivocality and uncertainty on information context.

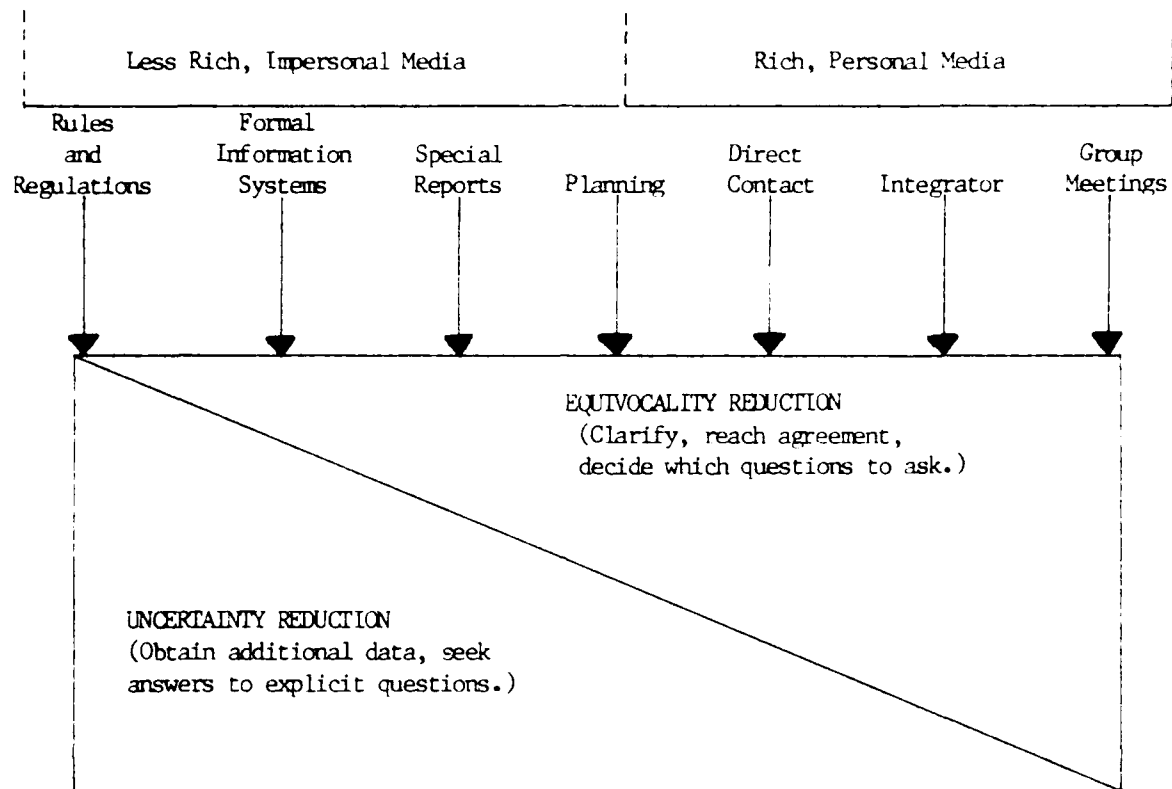


Figure 2. Information role of structural characteristics for equivocality or uncertainty reduction.

Unanalyzable

ANALYZABILITY

Analyzable

<p>1. Unanalyzable, Low Variety (Craft Technology)</p> <p><u>Structure:</u></p> <p>a. Rich media to resolve unanalyzability</p> <p>b. Small amount of information</p> <p><u>Examples:</u> Occasional face-to-face and scheduled meetings, planning, telephone.</p>	<p>2. Unanalyzable, High Variety (Nonroutine Technology)</p> <p><u>Structure:</u></p> <p>a. Rich media to resolve unanalyzability</p> <p>b. Large amount of information to handle exceptions</p> <p><u>Examples:</u> Frequent face-to-face and group meetings, unscheduled meetings, special studies and reports.</p>
<p>3. Analyzable, Low Variety (Routine Technology)</p> <p><u>Structure:</u></p> <p>a. Media of low richness</p> <p>b. Small amount of information</p> <p><u>Examples:</u> Rules, standard procedures, standard information system reports, memos, bulletins.</p>	<p>4. Analyzable, High Variety (Engineering Technology)</p> <p><u>Structure:</u></p> <p>a. Media of low richness</p> <p>b. Large amount of information to handle frequent exceptions</p> <p><u>Examples:</u> Data bases, plans, schedules, statistical reports, occasional meetings.</p>

Low

VARIETY

High

Figure 3. Relationships between department technology and information processing for task accomplishment.

DIFFERENCE BETWEEN DEPARTMENTS	High	<p>1. High Difference, Low Interdependence</p> <p><u>Structure:</u></p> <ul style="list-style-type: none"> a. Rich media to resolve differences b. Small amount of information <p><u>Examples:</u> Occasional face-to-face or telephone meetings, personal memos, planning, consultation.</p>	<p>2. High Difference, High Interdependence</p> <p><u>Structure:</u></p> <ul style="list-style-type: none"> a. Rich media to resolve differences b. Large amount of information to handle interdependence <p><u>Examples:</u> Full time integrators, task forces, teams, matrix structure, special studies and projects, confrontation</p>
	Low	<p>3. Low Difference, Low Interdependence</p> <p><u>Structure:</u></p> <ul style="list-style-type: none"> a. Media of lower richness b. Small amount of information <p><u>Examples:</u> Rules, standard operating procedures, reports, budgets.</p>	<p>4. Low Difference, High Interdependence</p> <p><u>Structure:</u></p> <ul style="list-style-type: none"> a. Media of lower richness b. Large amount of information to handle interdependence <p><u>Examples:</u> Plans, reports, update data bases, MIS's, clerical help, pert charts, budgets, schedules.</p>
		Low	High
		INTERDEPENDENCE BETWEEN DEPARTMENTS	

Figure 4. Relationship between interdepartment characteristics and information processing for coordination.

Cause-Effect
Relationships
Unanalyzable

ASSUMPTIONS
ABOUT
ENVIRONMENT

Cause-Effect
Relationships
Analyzable

<p>1. Unanalyzable, Certain</p> <p><u>Structure:</u></p> <p>a. Rich media to resolve equivocal cues</p> <p>b. Small amount of information</p> <p><u>Examples:</u> Irregular external contacts, casual information, professional associations, occasional meetings, delphi.</p>	<p>2. Unanalyzable, Uncertain</p> <p><u>Structure:</u></p> <p>a. Rich media to resolve equivocal cues</p> <p>b. Large amount of information to reduce uncertainty</p> <p><u>Examples:</u> Send agents to field, frequent meetings, project teams, trial and error, separate scanning position or department, dialectical inquiry.</p>
<p>3. Analyzable, Certain</p> <p><u>Structure:</u></p> <p>a. Media of lower richness</p> <p>b. Small amount of information</p> <p><u>Examples:</u> Regular record keeping and reports, rules, procedures, newspapers, trade magazines.</p>	<p>4. Analyzable, Uncertain</p> <p><u>Structure:</u></p> <p>a. Media of lower richness</p> <p>b. Large amount of information to reduce uncertainty</p> <p><u>Examples:</u> Special department, surveys, studies, formal reports, scanning services, bulletins.</p>

Passive

ORGANIZATIONAL INTRUSIVENESS

Active

Figure 5. Relationship between environmental characteristics and information processing for scanning and interpretation.

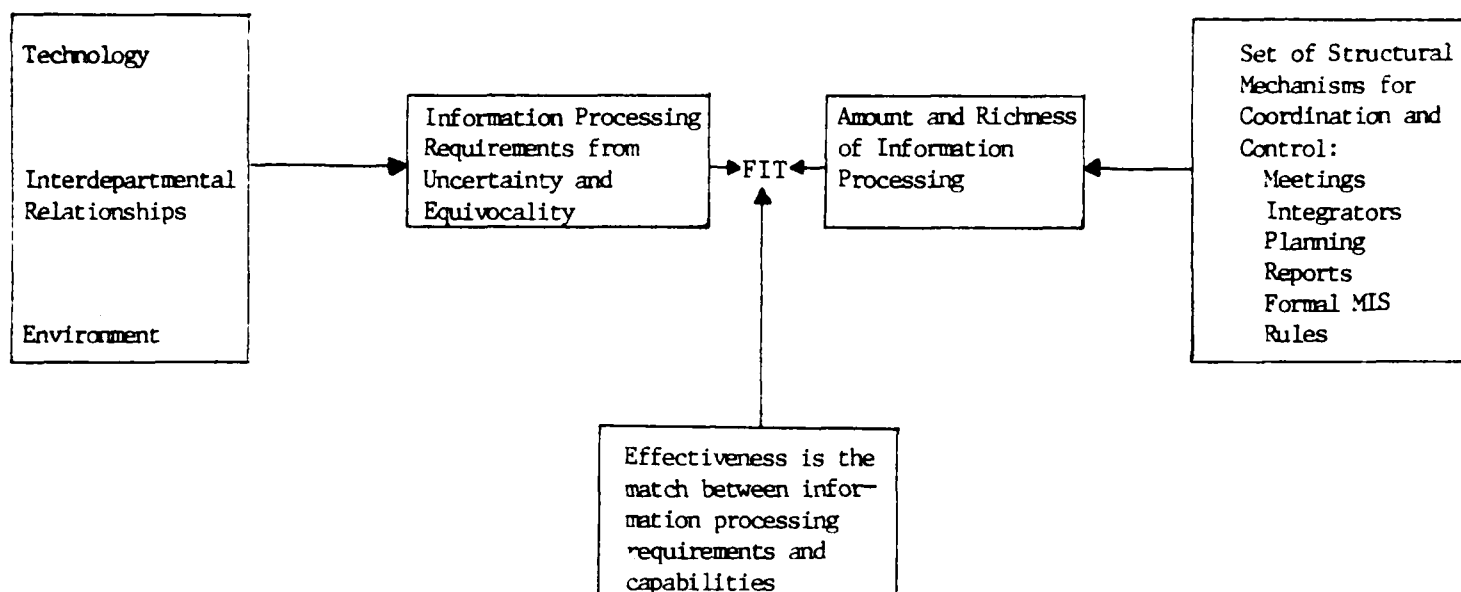


Figure 6. Summary model of information processing and organization design.

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